RESEARCH MEMORANDUM

PRELIMINARY RESULTS OF AN INVESTIGATION OF THE EFFECTS OF SPINNER SHAPE ON THE CHARACTERISTICS OF AN NACA D-TYPE COWL BEHIND A THREE-BLADE PROPELLER, INCLUDING THE CHARACTERISTICS OF THE PROPELLER AT NEGATIVE THRUST

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

An investigation has been conducted to determine the effects of spinner shape on the pressure-recovery characteristics of an NACA 1-series D-type cowl operating behind a three-blade single-rotation propeller. Two spinner shapes were considered, an NACA 1-series spinner and a modified spinner, more nearly conical than the 1 series. The aerodynamic characteristics of the propeller operating ahead of the cowling and also operating on the isolated 1-series spinner were also determined. The negative thrust characteristics of the propeller-spinner combination were measured at low speeds for blade angles from 25° to -20°.

Some of the results of this investigation are being made available in preliminary form in this report in order to expedite their release.

INTRODUCTION

At the present time there are several new turboprop-powered airplanes in an advanced stage of development. These airplane designs have the common problem of providing efficient air induction for the turbine engine.

It is the purpose of the present report to summarize the results of tests made to compare the ram-recovery characteristics of a D-type cowl behind a fairly thick three-blade propeller in combination with an NACA 1-series and a modified-conical spinner. Also, in summary, the maximum efficiency of the propeller operating ahead of the cowling is compared with the maximum efficiency of the propeller operating on the isolated 1-series spinner. The low-speed characteristics of the propeller

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operating under negative thrust on the isolated 1-series spinner are included.

The present results are offered without discussion in order to permit their release ahead of the more detailed results of the investigation.

SYMBOLS

a	speed of sound, ft/sec
b	blade width, ft
c_{l_d}	blade section design lift coefficient
C_P	power coefficient, $\frac{P}{\rho n^3 D^5}$
C_T	thrust coefficient, $\frac{T}{\rho n^2 D^4}$
D	propeller diameter, ft
$\frac{b}{D}$	blade width ratio
H	total pressure, lb/ft^2
$\frac{H_1-p_0}{H_0-p_0}$	ram-recovery ratio
h	maximum thickness of blade section, ft
$\frac{h}{b}$	blade thickness ratio
J	propeller advance ratio, $\frac{V_0}{nD}$
M_d	datum Mach number, $\frac{V}{a}$
n	propeller rotational speed, rps
P	power, ft-lb/sec

p static pressure, lb/ft^2

R propeller tip radius, ft

r blade-section radius, ft

T thrust, lb

T_c thrust coefficient, $\frac{T}{\rho V^2 D^2}$

V datum velocity (wind-tunnel air-stream velocity corrected for solid blockage of cowling but uncorrected for wind-tunnel-wall constraint on the propeller slipstream), ft/sec

V_o equivalent free-air velocity (datum velocity corrected for wind-tunnel-wall constraint on the propeller slipstream), ft/sec

$\frac{V_1}{V}$ inlet-velocity ratio

β propeller blade angle at 0.75R, deg

β_d design propeller section blade angle, deg

η efficiency, $\frac{TV_o}{P}$ or $\frac{C_T}{C_P} J$

ρ mass density of air, slugs/ft^3

Subscripts

o free stream

1 location of rake in cowling inlet

a apparent (applied to values of thrust, power, and efficiency measured for the propeller operating in the presence of the cowling)

max maximum

MODEL AND METHODS

The model of the cowl and propeller was mounted on the 1000-horsepower propeller dynamometer (described in ref. 1) in the test section of the Ames 12-foot pressure wind tunnel as shown in figure 1. Figure 2 is a sketch of the general model arrangement showing the principal model dimensions. The inlet area of the model was scaled (approximately 1/4 size) to match the air requirements of the Pratt-Whitney T-34 engine. Coordinates for the cowling and spinners are given in table I. The three-blade propeller used for this investigation has the designation NACA 3.638-(675)(057)-0572. Blade-form curves for the propeller are presented in figure 3. The platforms between the propeller blades and the spinners were fixed to the spinners at a local blade angle of 83° and had the dimensions and coordinates given in figure 2 and table I, respectively.

The instrumentation of the cowl and the methods used in obtaining ram-recovery ratio and inlet-velocity ratio were the same as described in reference 2, except that for this investigation the total- and static-pressure rakes were made up of six tubes each in place of the eight-tube rakes employed in the tests of reference 2. The methods used in determining the thrust, power, and efficiency of the propeller when operating on an isolated spinner and when operating ahead of a cowling were the same as described in references 1 and 3, respectively. For the propeller operating under negative thrust at the larger negative blade angles, the minimum advance ratio was limited to the corresponding value of T_c at which the theoretical effects of the tunnel walls could be confirmed from measurements of wall pressures.

TESTS AND RESULTS

Summary curves showing the ram-recovery ratio as a function of inlet-velocity ratio for the cowl with the two different spinner shapes are presented in figure 4 for Mach numbers from 0.2 to 0.8 with the propeller removed. Similar data are presented in figure 5 for the propeller operating at various combinations of Mach number, blade angle, and advance ratio.

The maximum apparent efficiency of the propeller operating ahead of the D-type cowl is shown as a function of Mach number and blade angle in figure 6. These data are all for an inlet-velocity ratio of approximately 0.5. The maximum efficiency of the propeller with the 1-series spinner with the cowl removed is also shown in this figure. Note that at the higher Mach numbers (0.70 and 0.80) the propeller blade angle is so large that the inner portions of the blade are at local angles greater than 90°. Stress limitations of the model propeller prevented testing at a higher rotational speed and, thus, the propeller characteristics at lower blade angles could not be measured at these Mach numbers.

The aerodynamic characteristics of the propeller operating under conditions of negative thrust at a forward Mach number of 0.15 are shown in figure 7 as a function of advance ratio and in figure 8 as a function of propeller blade angle.

All data presented herein were obtained at a Reynolds number of 1.0 million per foot, based on the datum velocity.

Ames Aeronautical Laboratory
National Advisory Committee for Aeronautics
Moffett Field, Calif., Oct. 2, 1953

REFERENCES

1. Reynolds, Robert M., Buell, Donald A., and Walker, John H.: Investigation of an NACA 4-(5)(05)-041 Four-Blade Propeller With Several Spinners at Mach Numbers Up to 0.90. NACA RM A52I19a, 1952.

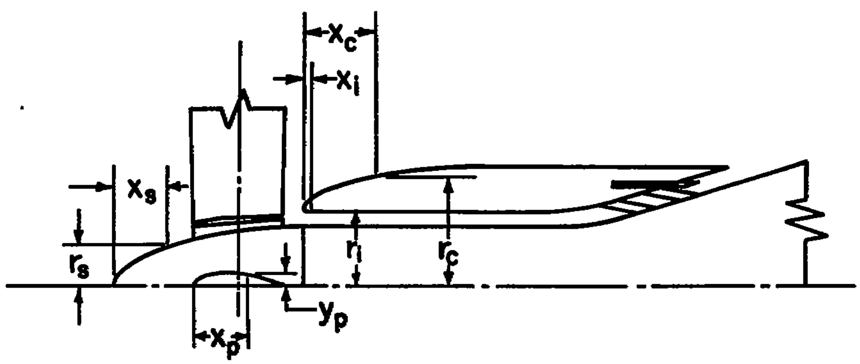
2. Sammonds, Robert I., and Molk, Ashley J.: Effects of Propeller-Spinner Juncture on the Pressure Recovery Characteristics of an NACA 1-Series D-Type Cowl in Combination With a Four-Blade Single-Rotation Propeller at Mach Numbers Up to 0.83 and at an Angle of Attack of 0°. NACA RM A52D01a, 1952.

3. Reynolds, Robert M., Sammonds, Robert I., and Kenyon, George C.: An Investigation of a Four-Blade Single-Rotation Propeller in Combination With an NACA 1-Series D-Type Cowling at Mach Numbers Up to 0.83. NACA RM A53B06, 1953.

TABLE I.- COWLING-SPINNER COORDINATES

[Coordinates in inches]

Distance from leading edge of cowl, x_c	NACA 1-62.8-070 cowl, radius, r_c	Distance from leading edge of cowl, x_i	NACA 1-series inner lip, radius, r_i	Distance from leading edge of 1-series spinner x_s	NACA 1-50-74.6 spinner, radius, r_s	Distance from leading edge of modified-conical spinner, x_s	Modified-conical spinner, radius, r_s	Distance from leading edge of platform juncture, x_p	Platform juncture ordinate, y_p
0	4.460	0	4.460	0	0	0	0	0	0
.020	4.581	.008	4.439	.063	.284	.065	.227	.125	.343
.039	4.628	.017	4.429	.105	.363	.121	.329	.249	.470
.059	4.666	.034	4.415	.157	.445	.181	.401	.498	.650
.078	4.697	.050	4.403	.209	.516	.241	.471	.996	.873
.098	4.723	.067	4.394	.261	.580	.303	.530	1.494	.985
.196	4.834	.084	4.386	.314	.641	.362	.594	1.992	1.019
.490	5.078	.101	4.378	.419	.751	.483	.700	2.490	.946
.980	5.377	.118	4.372	.627	.945	.725	.889	2.989	.803
1.372	5.569	.134	4.366	.837	1.114	.966	1.047	3.487	.628
1.764	5.727	.168	4.355	1.255	1.403	1.450	1.325	3.985	.435
2.156	5.866	.202	4.346	1.777	1.693	1.933	1.549	4.483	.240
2.548	5.993	.244	4.337	2.195	1.891	2.416	1.743	4.981	0
2.940	6.108	.277	4.331	3.136	2.271	3.382	2.062	---	---
3.332	6.215	.311	4.326	3.972	2.553	4.349	2.340	---	---
3.724	6.313	.344	4.323	4.913	2.817	5.307	2.597	---	---
4.116	6.403	.378	4.320	5.854	3.035	6.277	2.819	---	---
4.508	6.485	.420	4.320	6.690	3.192	7.248	3.008	---	---
4.900	6.560	---	---	7.526	3.316	8.197	3.173	---	---
5.684	6.694	---	---	8.572	3.425	9.167	3.307	---	---
6.468	6.802	---	---	9.408	3.478	10.139	3.426	---	---
7.252	6.885	---	---	9.826	3.494	10.613	3.476	---	---
8.036	6.946	---	---	10.244	3.499	10.814	3.499	---	---
8.820	6.985	---	---	10.453	3.499	---	---	---	---
9.800	7.000	---	---	---	---	---	---	---	---



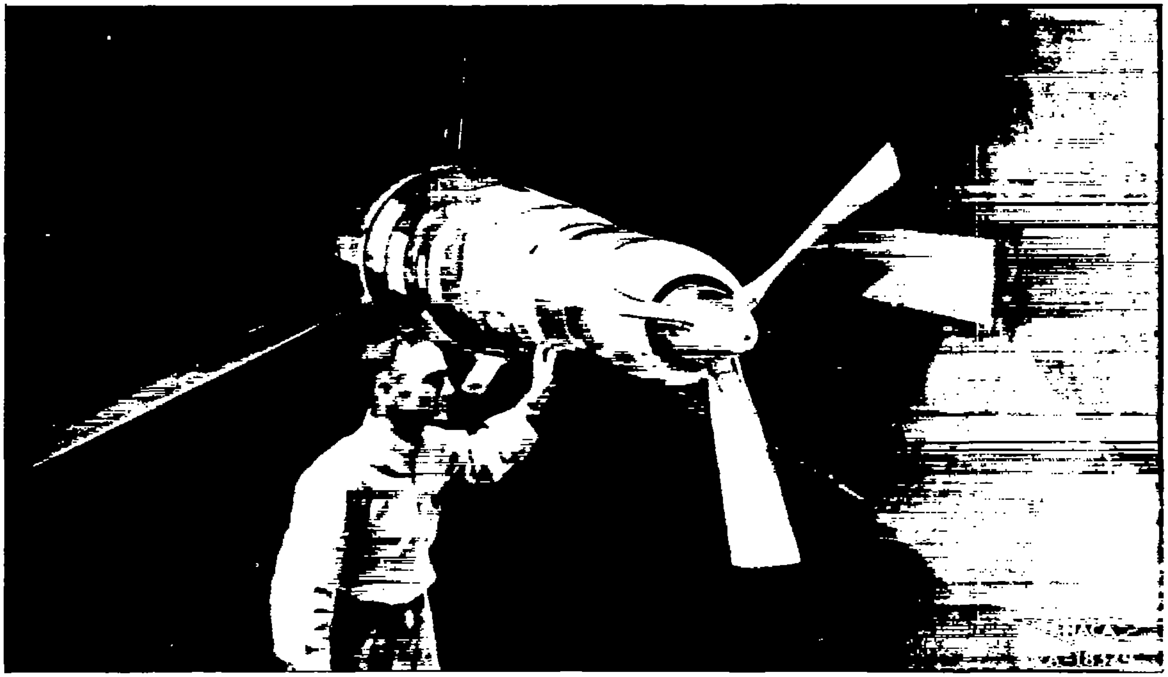


Figure 1.- The model mounted on the 1000-horsepower propeller dynamometer in the 12-foot pressure wind tunnel.

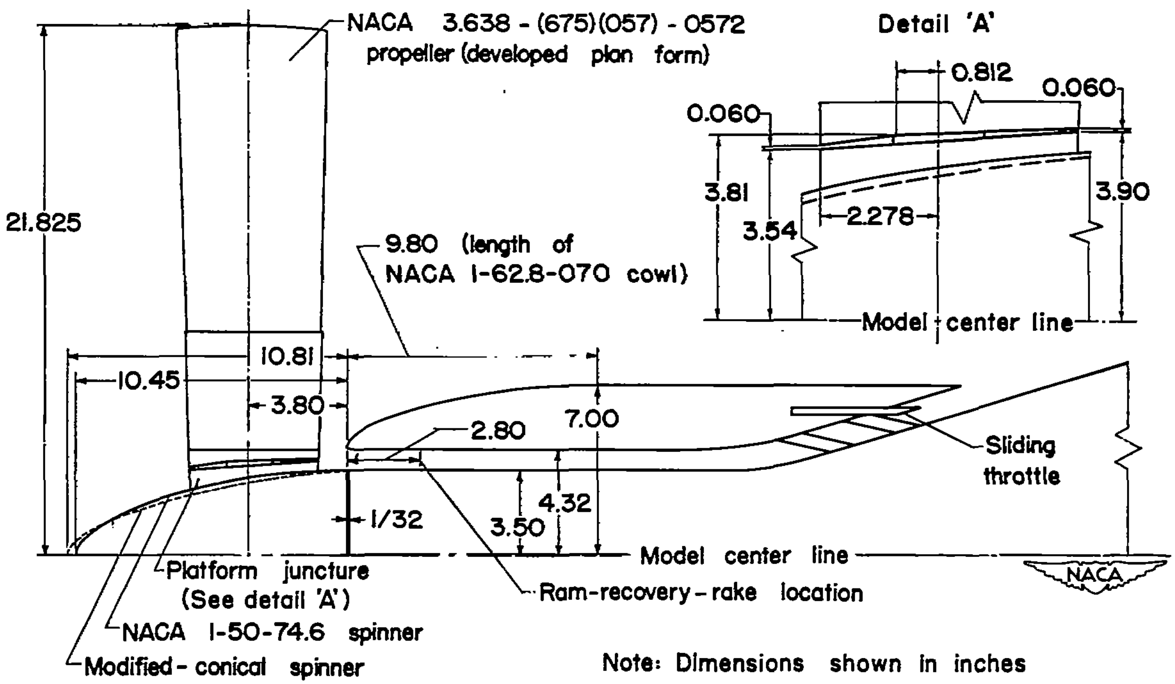


Figure 2.- Model arrangement.

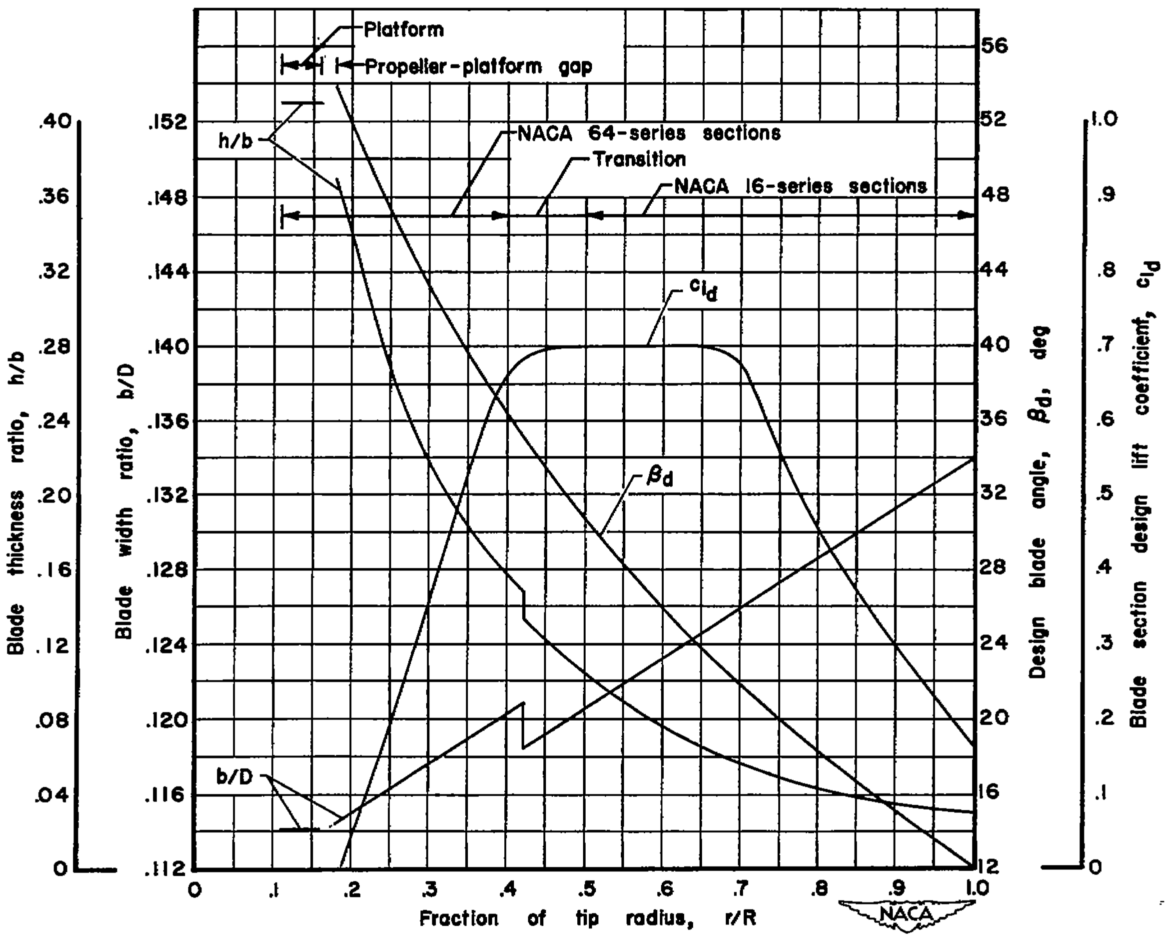


Figure 3.- Plan-form and blade-form curves for the model propeller having the designation NACA 3.638-(675)(057)-0572.

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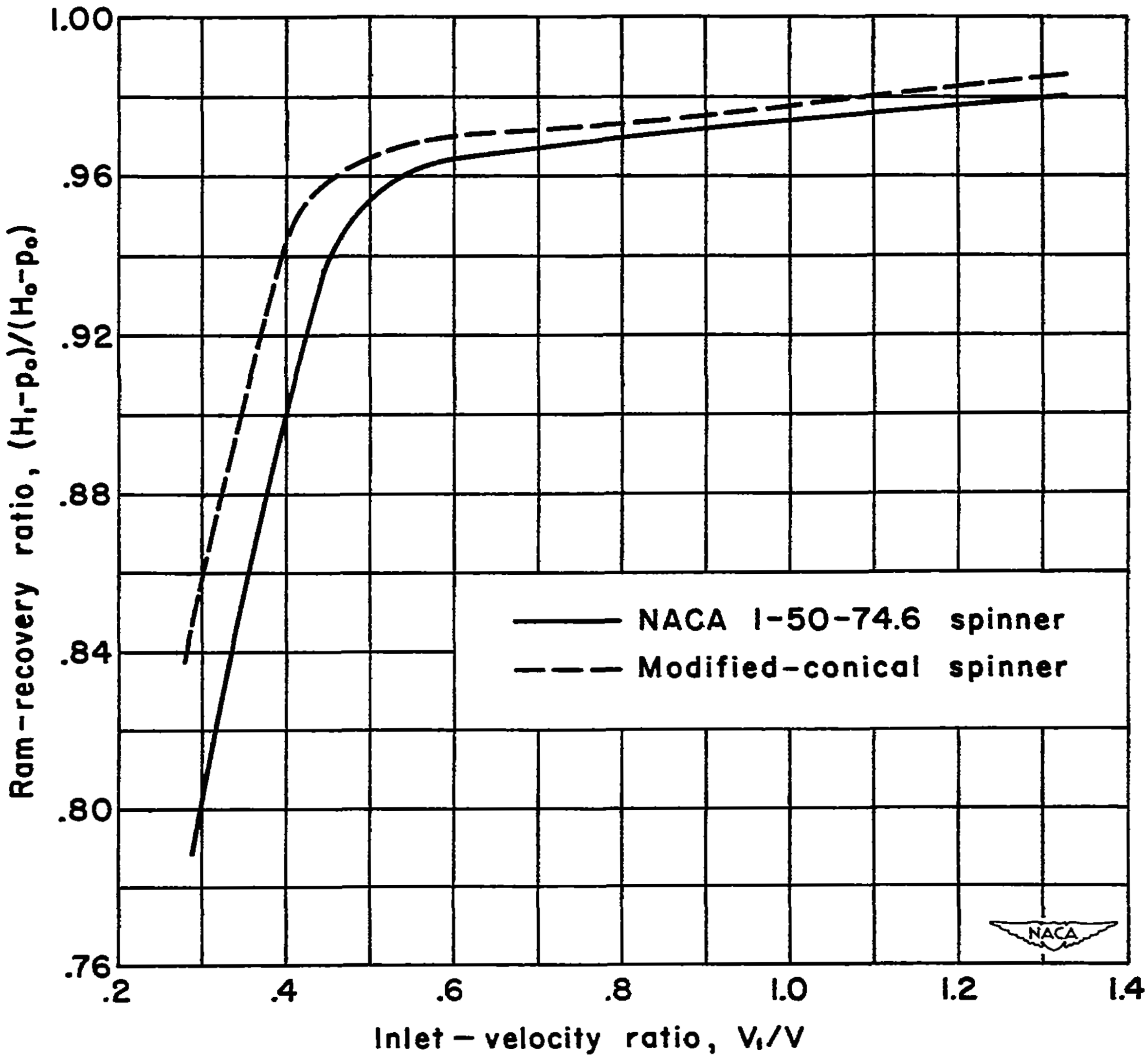
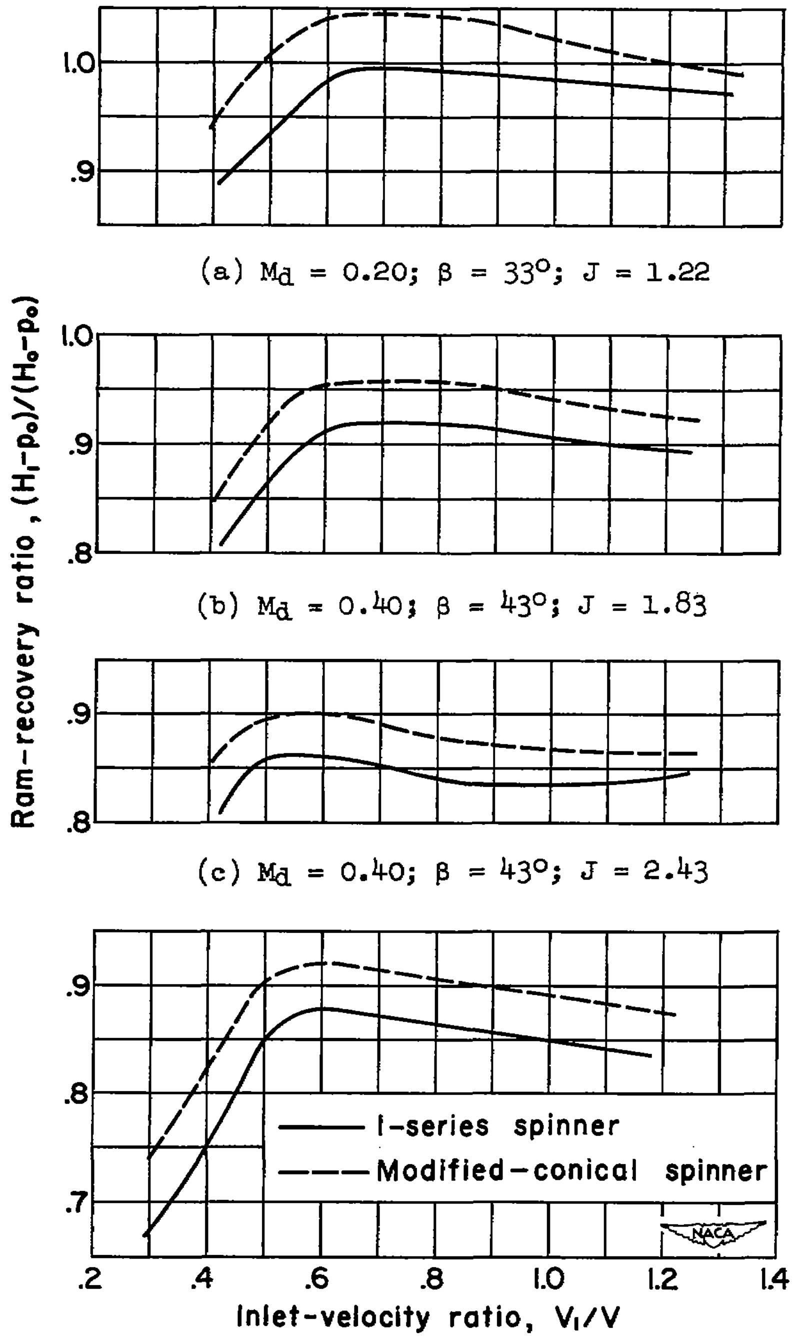


Figure 4.- The effect of inlet-velocity ratio on the average ram-recovery ratio for the cowl with 1-series and modified-conical spinners, propeller removed. Mach numbers from 0.20 to 0.80.



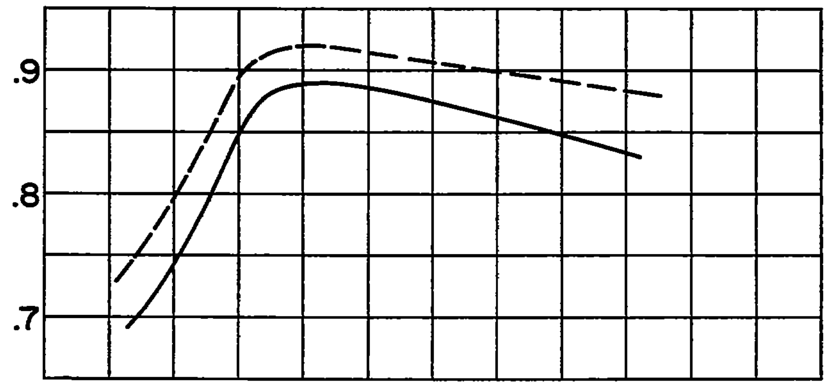
(a) M_d = 0.20; β = 33°; J = 1.22

(b) M_d = 0.40; β = 43°; J = 1.83

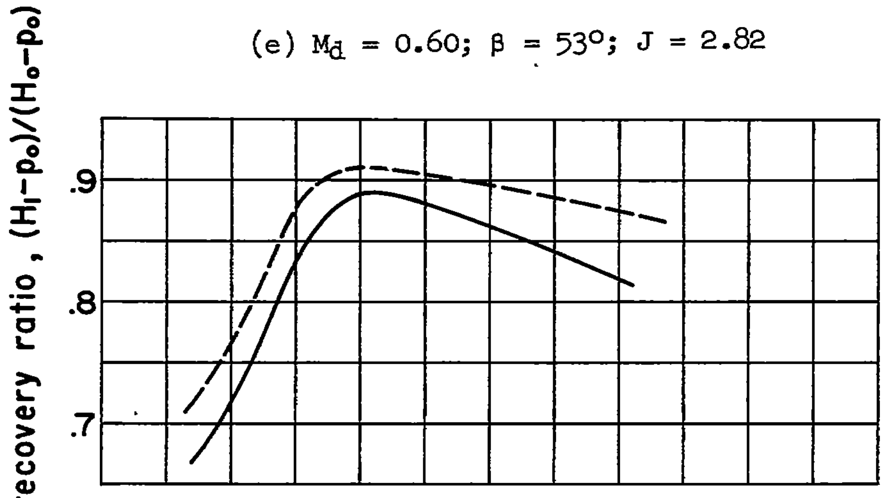
(c) M_d = 0.40; β = 43°; J = 2.43

(d) M_d = 0.50; β = 48°; J = 2.45

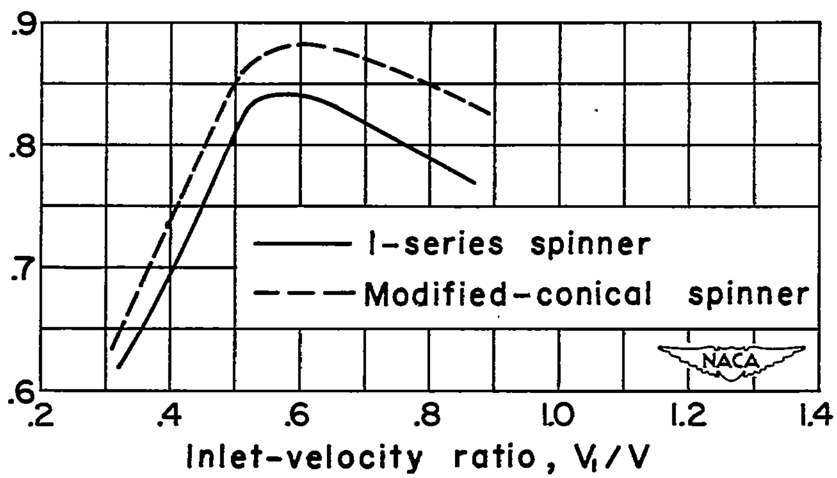
Figure 5.- The effect of inlet-velocity ratio on the average ram-recovery ratio for the cowl with 1-series and modified-conical spinners, propeller operating.



(e) $M_d = 0.60$; $\beta = 53^{\circ}$; $J = 2.82$



(f) $M_d = 0.70$; $\beta = 58.5^{\circ}$; $J = 3.40$



(g) $M_d = 0.80$; $\beta = 58.5^{\circ}$; $J = 3.30$

Figure 5.- Concluded.

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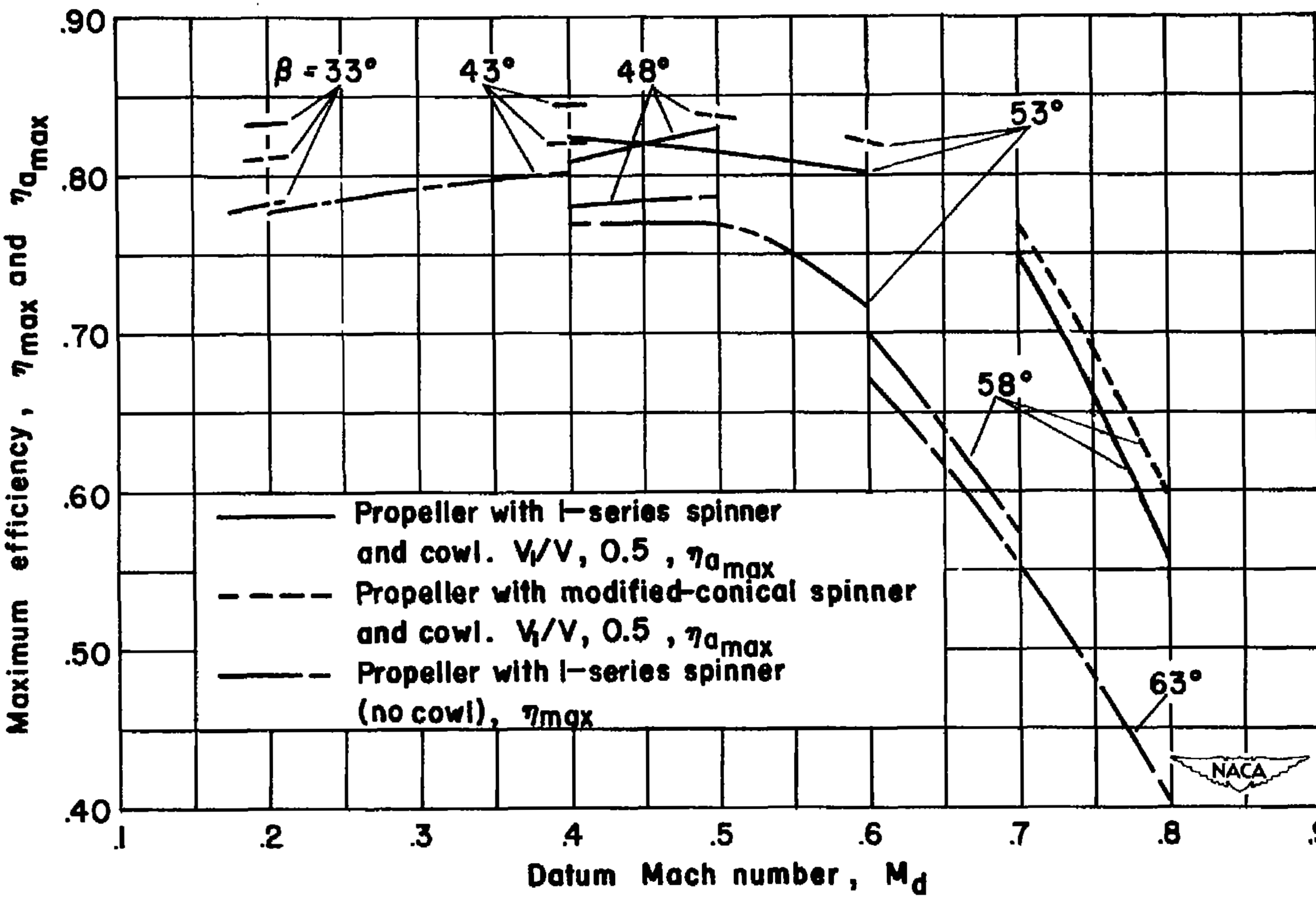
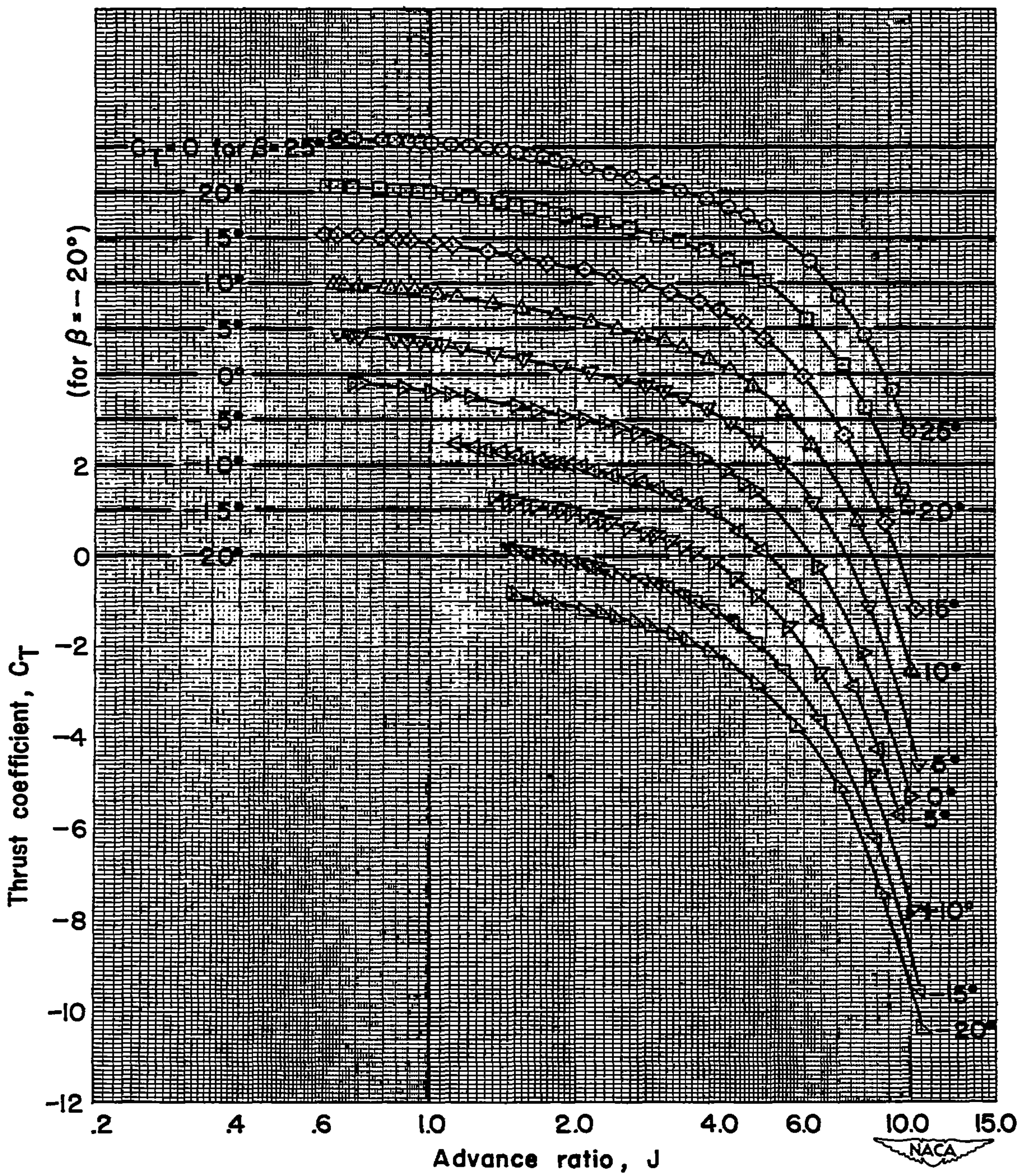
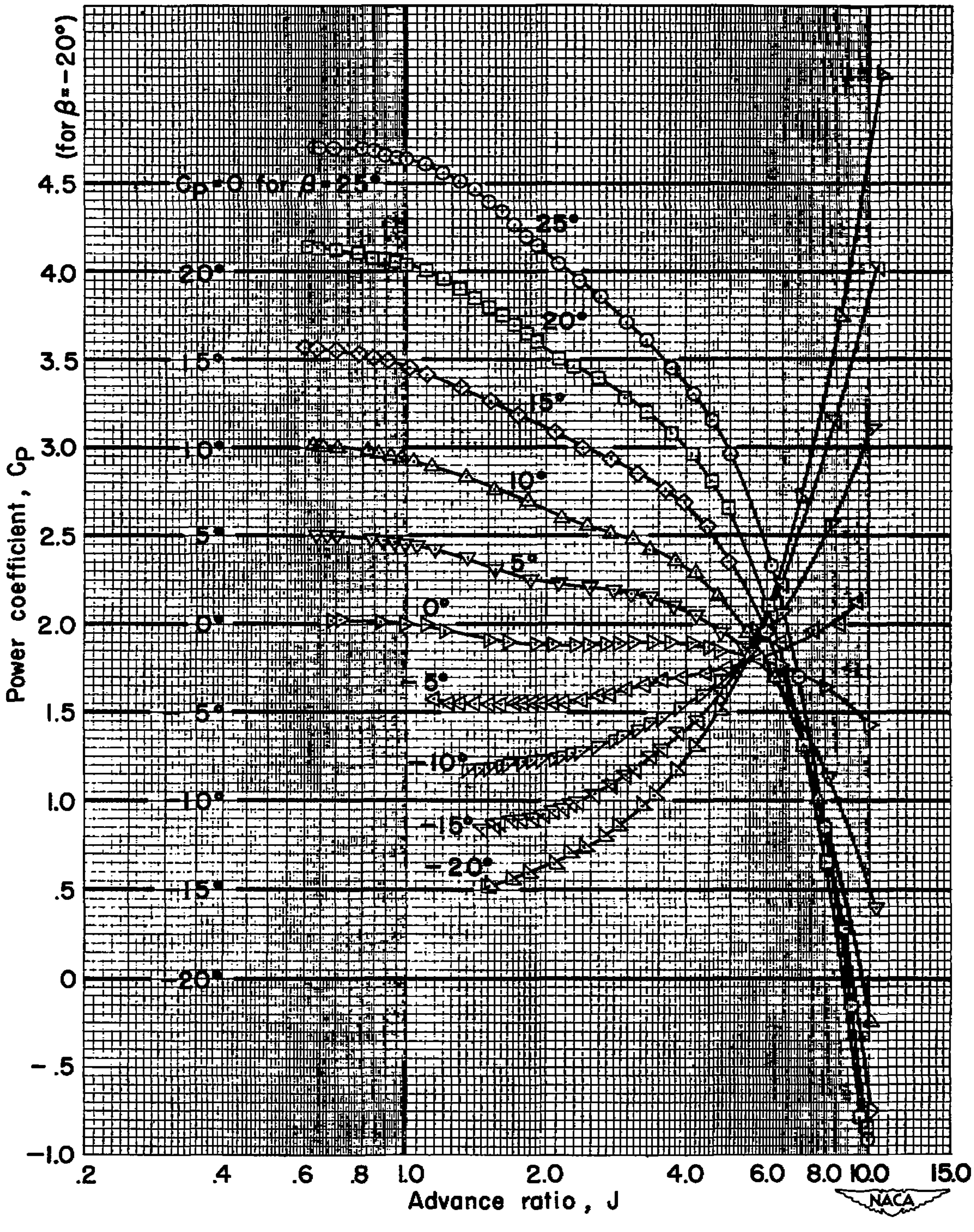


Figure 6.- The effect of Mach number on the maximum efficiency of the propeller.



(a) C_T vs. J

Figure 7.- Characteristics of the propeller in negative thrust; $M_d = 0.15$.



(b) C_P vs. J

Figure 7.- Concluded.

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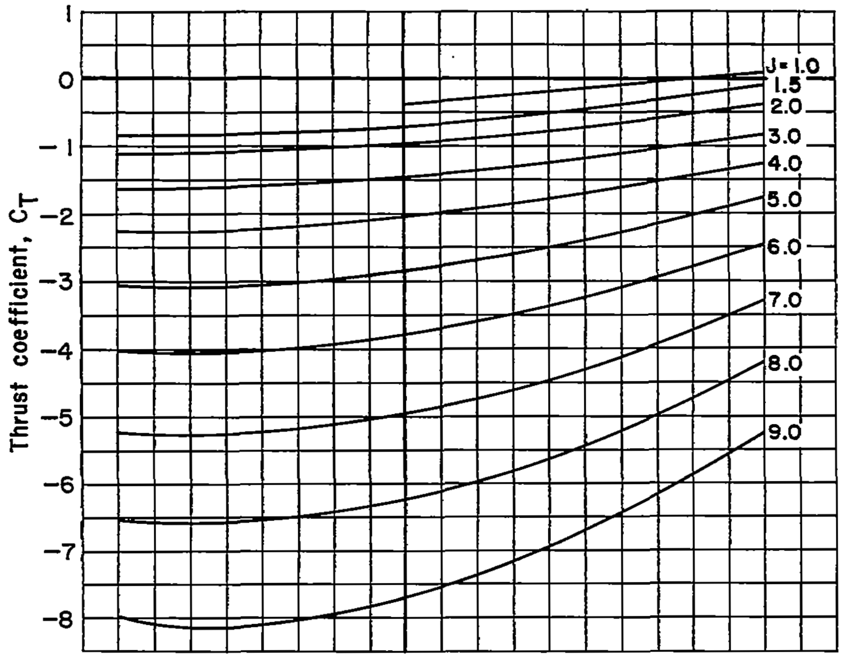
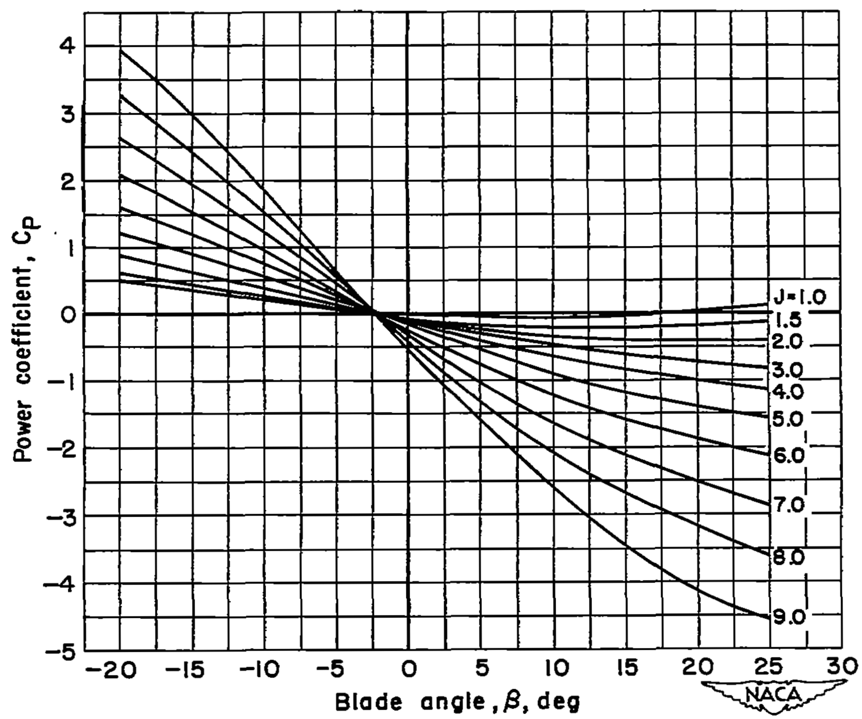


(a) C_T vs. β



(b) C_P vs. β

Figure 8.- The effect of blade angle on the characteristics of the propeller in negative thrust; M_d = 0.15.

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SECURITY INFORMATION

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